Summary

Using reverse osmosis, the saline groundwater from the shallow aquifer was desalted. The product water would be suitable for use as irrigation water.

The RO demonstration plant operated periodically throughout the 2000 and continuously throughout the 2002 irrigation seasons using two different feedwater sources to produce the permeate. During 2000 the water used in the RO demonstration plant came from the on-farm tile drain system that was installed by the farmers to keep the saline groundwater below the crop root zone and to transport the drainage water away from the crops. During 2002, two shallow wells were used to supply water to the RO demonstration plant. The water from the two wells was 57 % less salty than that of the tile drain system.

The RO demonstration plant recovered up to 75% of the feed water and rejected as much as 90% of the organics and 97% of the TDS. Alum was injected ahead of the filter system to promote coagulation and to increase solid settling to obtain RO feedwater with an acceptable SDI. The prefiltration did not reduce the TOC concentration in the raw water.

The RO Demonstration Project has shown that it is technically feasible to reclaim agricultural drainage water in the San Joaquin Valley using reverse osmosis. A suitable method for disposing of the concentrate must be determined before implementation is possible.

Future Study

Future studies should focus mainly on RO process brine disposal. **Table 9** shows the brine concentrate quality data captured during the pilot study.

Table 9. Concentrate Quality

Constituent (mg/L)	Field Data
Calcium	1,215
Magnesium	218
Sodium	3,200
Potassium	0
Ammonium	0
Barium	0
Strontium	9
Iron	5
Aluminum	0
Bicarbonate	725
Chloride	5,238
Sulfate	3,192
Fluoride	0
Nitrate	0
Phosphate	0
Silica	99
pH (pH units)	7.20
TDS	12,079

There are multiple ways to dispose of RO concentrate, including:

- Evaporation Ponds
- Deep Well Injection
- Disposal to a Body of Water (i.e. Ocean or River)
- Enhanced Recovery (Zero Liquid Discharge)

Evaporation Ponds

Disposal of wastewater (including desalting concentrate) via evaporation ponds has been used for many years. There are several design aspects of evaporation ponds that need to be considered:

- The net evaporation rate (gross evaporation less precipitation and decrease in evaporation rate as TDS increases)
- Land requirements—the area required depends on the volume of water requiring disposal, net evaporation rate, and topography (a level site would require the least land for a given evaporation surface need)
- Number and size of ponds
- Impermeable lining for minimizing leakage into underlying groundwater
- Impacts of trace elements (i.e. sodium) on water flow and biological resources

Assuming a net evaporation rate of 5 feet per year, **Table 10** shows the surface areas of evaporation ponds that would be needed for various treatment plant sizes.

Table 10. Needed Evaporation Pond Area for Varying Production Rates

Plant Productions (MGD)	**1**	**2**	**5**	**10**
Concentrate (AFY)	326	637	1,587	3,178
Evaporation Area (acres)	65	127	317	636
Number of Ponds	2	4	8	16
Size of Each Pond (acres)	35	35	40	40
Total Pond Area (acres)	70	140	320	640
Total Area Needed (acres)	75	150	345	690

A typical pond may have a total depth of 12 ft (including 2 ft of freeboard) and side slopes of 3 to 1.

Deep Well Injection

An alternative to evaporation ponds is deep well injection (DWI). DWI consists of drilling a well into an aquifer that does not contain usable water to dispose of the concentrate. The aquifer needs to be deep enough so as not to interfere with usable groundwater.

Disposal to a Body of Water

Another alternative is to dispose of concentrate to a body of water. Typical bodies of water used for disposal include the ocean or nearby rivers and streams. Since this project takes place inland from the ocean, a pipeline would have to be constructed to carry the concentrate from the treatment site.

In order to dispose to a body of water like a river or stream, state and local regulatory agencies insist that the water quality be nontoxic to whatever wildlife may inhabit the waterway. Typical RO waste streams are high in TDS concentration and are difficult to dispose of in a body of water.

Enhanced Recovery

By further treating the concentrate or enhancing the recovery, more useable water and less concentrate is produced. At this point, the brine becomes a highly concentrated waste that can be either disposed of or precipitated for salt recovery.

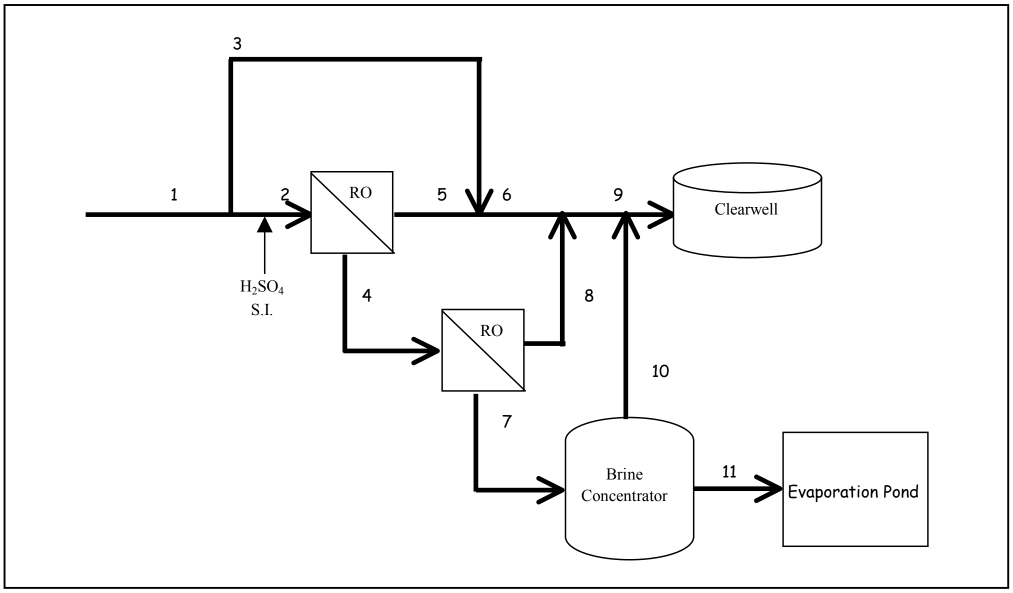
Secondary RO Treatment

Depending on the TDS concentration and the ionic makeup of the concentrate, more usable water can be recovered using a second RO unit. However, since the concentrate from the primary RO treatment is saturated in scaling minerals, it must first be treated to remove these minerals before secondary RO treatment.

Zero Liquid Discharge (ZLD)

ZLD is another form of enhanced recovery. This can be achieved by using equipment such as brine concentrators and/or crystallizers to remove essentially all of the water from the concentrate. The TDS that was dissolved in the original raw water are recovered as relatively dry salts. (see **Figure 18**).

Figure 18: Enhanced Recovery Block Flow Diagram



Stream	1	2	3	4	5	6	Y_1%*
gpm	782	707	75	177	530	605	75%
TDS	3,848	3,861	3,848	14,936	170	626	
Stream	**7**	**8**	**9**	**10**	**11**	**Y_2%***	**Y_O%***
gpm	88.4	88	**772**	78	10	50%	98.7%
TDS	28,340	1,532	**668**	20	240,000		

*Y = Percent recovery for each stage of production ("1" & "2") and overall production ("o").

Typically, what's left over after the enhanced recovery process is a highly concentrated sludge. This sludge can be disposed of in drying beds or evaporation ponds to remove what little liquid remains. Once dry, the solid can be hauled off for disposal. Assuming a sludge handling cost of $53/ton[6], the annual cost to remove the sludge would approximate $283,000 dollars for 5,300 tons of sludge waste.

[6] Waste disposal estimate provided by J Torres Company.